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PREDICTING THE LOSSES IN SAWTIMBER VOLUME AND QUALITY FROM FIRES IN OAK-HICKORY FORESTS

1. lumber value losses in dollars
2. volume losses in board feet
3. length of defect in feet
4. cross sectional area of defect in square inches

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THIS IS ANOTHER OF OUR "NEW LOOK" RESEARCH PAPERS, designed (hopefully) to serve the special needs of each of our two major clients: the practitioner and the scientist.

Realizing that the needs and interests of our two major "clients"--the scientists and the practitioner--are different, we have been concerned whether our publications have been in a form and style equally useful to both. So we have decided to try a new format for some of our Research Papers, one that might serve this dual purpose better. You are about to sample the first fruit of this effort.

The Paper is divided into two separate parts: Application and Documentation. The Application section is specifically intended for the man on the ground or in the mill who has a particular job to do or problem to solve. This section describes briefly the situation and the problem, and then goes immediately to the solution, emphasizing the how-to-do-it aspect. It is a complete story in itself; the busy manager need read no further.

The Documentation section describes the details of the research process. It is for the reader interested in laboratory and field procedures, tabulations, statistical analysis, and philosophical discussion. This section, too, is self-contained.

Our purpose is to separate the practical aspects of our research results from the strictly academic ones yet still make both available to all readers. If the practitioner wants to find out how we arrived at our recommendations, the details are in the Documentation section for him to examine. If the scientist has a practical bent, he can turn to the Application section and see the results in action.

It is for you to decide whether we have created a well-matched team or a two-headed monster. *We would like to have your opinion*.

PREDICTING THE LOSSES IN SAWTIMBER VOLUME AND QUALITY FROM FIRES IN OAK-HICKORY FORESTS

Robert M. Loomis

A P P L I C A T I O N

Whether trees are killed or only damaged in a forest fire, there are losses to the forest owner. Losses are soon apparent if the trees are killed, but losses due to injury may not be obvious for many years, perhaps not until harvest. Basal fire wounds provide a threshold for insects and decay which may eventually kill the tree or reduce the quantity and quality of usable wood at harvest time (fig. 1).

We have found a way to predict sawtimber losses due to fire wounding by taking a few simple measurements and substituting them in some damage estimate equations we have developed. The equations apply to northern red, black, scarlet, white, and chestnut oaks for all sites in the oak-hickory type. The equations apply to oaks that have basal fire wounds from a single fire and that are expected to survive until harvestable. Any tree having a fire wound extending more than two-thirds (one-half for scarlet oak) of the circumference at 1 foot above the ground is unlikely to survive until harvest time. The equations do not apply to trees that already have butt rot. The prediction equations are most applicable for State and regional timber surveys of fire damage. They may also be used for individual fires and stands but the estimates will be less accurate.

The equations predict: (1) lumber value losses, (2) volume losses, (3) length of scalable defect above stump height, and (4) cross sectional area of the scalable defect at stump height.

Figure 1.--*Basal fire wound on oak tree.*

To use the equations, the following data are needed: (1) d.b.h. outside bark in inches at time the tree was wounded, (2) wound length in feet above a 1-foot stump, (3) wound width in inches measured as an arc 1 foot above ground, (4) the logarithm (base 10) of the estimated number of years before the tree will be cut, and (5) current or predicted future selling price per board foot of No. 1 common 4/4 lumber of same species.

Wound measurements are most easily made a year or two after a fire when wounds are more evident. If appraisals are made immediately after a fire, the procedure given in an earlier manuscript (Loomis 1973) should be used.

Suppose a black oak is damaged by fire and its measurements are:

DBH outside bark at time tree was wounded=10 inches.
Wound length (WL) above a 1-foot stump=4.5 feet.
Wound width (WW) at 1 foot above ground=15 inches.
Logarithm (base 10) (L) of estimated number of years before tree will be cut =logarithm of 30=1.477.
Current selling price (SP) of No. 1 common 4/4 lumber of same species=$150 per 1,000 fbm or $0.15 per board foot.

To predict the losses, simply "plug in" the data called for in the following four equations.

Lumber Value Loss

To predict lumber value loss in this tree 30 years in the future use the equation:

$$\begin{aligned}\text{lumber value loss} &= SP[-82.45+3.08(WL)\\ &\quad +38.94(L)+2.18(DBH)\\ &\quad +0.71(WW)],\\ &= 0.15[-82.45+3.08(4.5)\\ &\quad +38.94(1.477)+2.18(10)\\ &\quad +0.71(15)],\\ &= \$3.20.\end{aligned}$$

Volume Loss

To predict volume loss (International 1/4-inch scale) for this tree 30 years in the future use the equation:

$$\begin{aligned}\text{volume loss} &= -79.14+3.82(WL)+41.14(L)\\ &\quad +1.54(DBH)+0.59(WW),\\ &= -79.14+3.82(4.5)\\ &\quad +41.14(1.477)\\ &\quad +1.54(10)+0.59(15),\\ &= 23 \text{ fbm.}\end{aligned}$$

Length of Scalable Defect

To predict the length of scalable defect above stump height for this tree 30 years in the future use the equation:

$$\begin{aligned}\text{length of scalable defect} &= -2.88+0.98(WL)\\ &\quad +2.37(L)+0.07(WW),\\ &= -2.88+0.98(4.5)\\ &\quad +2.37(1.477)\\ &\quad +0.07(15),\\ &= 6 \text{ feet.}\end{aligned}$$

Cross Sectional Scalable Defect

To predict the cross sectional area of scalable defect at stump height for this tree 30 years in the future use the equation:

$$\begin{aligned}\text{cross sectional scalable defect} &= -185.09+4.67(WL)+111.10(L)\\ &\quad +5.13(DBH)+1.32(WW),\\ &= -185.09+4.67(4.5)+111.10(1.477)\\ &\quad +5.13(10)+1.32(15),\\ &= 71 \text{ square inches.}\end{aligned}$$

DOCUMENTATION

The 253 oak study trees used to develop the foregoing equations were found in Missouri, Pennsylvania, Kentucky, Ohio, Illinois, and Indiana. They were dominants or codominants of sawtimber size growing on medium or better sites (50 to 90 site index) for black oak (Schnur 1937). Any fire-caused volume loss or log grade change on the lower bole was used in the analysis. Sometimes a damaged bole was as long as 32 feet. Basal fire wounds ranged in age from 6 to 87 years. The trees were felled and the boles scaled and graded by logs in two ways: (1) ignoring fire wounds and associated losses in volume and grade but deducting other normal defect, and (2) deducting losses in volume and grade due to fire as well as other normal defects. The boles were scaled using the International 1/4-inch Rule (USDA Forest Service 1964); logs were graded according to a USDA Forest Service guide (1965).

The board foot volume figures for logs were multiplied by "quality index" (Q.I.)[1] and the sum of the products per tree for "fire" were subtracted from the products for "no fire" to give a "lumber value loss factor."

The four prediction equations in the application section were produced by stepwise regression (Dixon 1968). The coefficient of determination and standard error of the estimate were as follows:

Equations	R^2	Syx
Lumber value loss=SP[-82.45 +3.08(WL)+38.94(L)+2.18(DBH) +0.71(WW)]	0.45	17.03
Volume loss=-79.14+3.82(WL) +41.14(L)+1.54(DBH) +0.59(WW)	.54	15.02
Length scalable defect=-2.88 +0.98(WL)+2.37(L)+0.07(WW)	.73	1.92
Cross sectional area scalable defect=-185.09+4.67(WL) +111.10(L)+5.13(DBH)+1.32(WW)	.48	32.81

The analysis included four dependent variables (lumber value loss factor, volume loss, length of defect, and cross sectional area of defect) and four independent variables (wound length above a 1-foot stump, wound width at 1 foot (stump height), wound age, and d.b.h. outside bark at time of fire).

Regression analysis showed all four independent variables to be significant for prediction of lumber value loss factor, volume loss, and cross sectional area of defect for all oak species combined. The variable, d.b.h. outside bark at time of fire, did not contribute significantly in predicting length of scalable defect for all oak species combined.

Wound length was found to be the best single predictor of the four dependent variables. This variable was followed by wound age (time from wounding to harvest), tree d.b.h. outside bark, and by wound width as regression variables in the selection process.

The decision to combine oak species was based on covariance analysis, consideration of number of trees, variable range, and examination of residuals by species over independent variables. For the oaks as a group, 70 percent of lumber value loss was due to volume loss and 30 percent to quality loss.

[1]Quality index (Q.I.) was developed by Herrick (1946) and used by McCauley and Mendel (1969) and Mendel and Smith (1970). Indexes for the factory grade logs of northern red, black, scarlet, and white oaks were from Mendel and Smith (1970); chestnut oak from McCauley and Mendel (1969); subfactory grade logs from lumber yield tables (Hanks 1973). All indexes for Appalachian hardwoods were based on 1964-68 prices, f.o.b. mills, Johnson City, Tennessee (Lemsky 1964-68); chestnut oak based on 1962-66 prices.

The equations in the application section are usable over a range of sites in commercial oak-hickory forests because the predictions are independent of merchantable height. However, site (including local microclimate) does affect volume and quality loss indirectly by influencing variables such as probability of decay entry, potential butt log quality, growth, and healing rates.

Wound Length

Wound length was the best predictor of the two wound dimensions considered. Hepting (1941) recognized that wound height affected amount of cull, but since wound height was unavailable he used wound width and wound age for predicting cull following fire in Appalachian oaks. Toole (1959) predicted the length of heart rot that extended from the wound top upward in southern bottomland hardwoods by using wound width, stump diameter, and wound age.

Wound Age

The longer a tree has been injured, the greater the chance that the injury will be attacked by wood destroying pathogens. Once decay starts, however, the rate of decay depends on other factors besides wound age: the resistance of the species to decay, the size of the wound, and the rate that the tree forms callus tissue to close the wound. Jensen (1969) presents evidence that supports the hypothesis that a wound must be open to maintain an active decay column. Also, the larger the wound, the longer it takes callus to close it and thus the more extensive the decay that may develop.

Tree Size

Decay following injury does not usually extend into the new growth of the tree (fig. 2). The larger the tree at time of injury, the greater the probability of volume and quality loss. Saplings, even though they develop rot after wounding, usually heal rapidly thus confining the defect to a small area within the tree center where it is least important. Because pole-sized and small sawtimber trees are nearing harvestable size, much volume and quality can be lost to decay if wounds do not heal promptly (fig. 3).

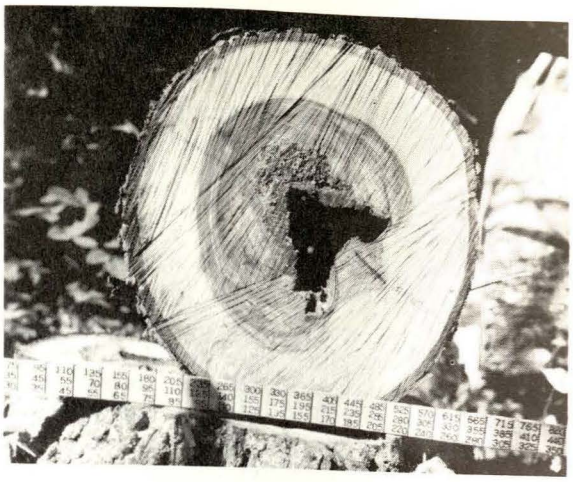

Figure 2.--*This hickory (now 14.8 inches d.b.h.) was only 7.5 inches d.b.h. when wounded. Decay did not spread to new growth.*

Figure 3.--*Where decay causes hollowing of tree bole, the callus growth may curl inward thus permitting an opening that may exist for many years. After 22 years the wound on this section of 50-year-old scarlet oak still had not closed.*

Trees nearing the size for cutting suffer little if cutting is not delayed too long because most of the defect may be removed with the slab in sawing.

Wound Width

In general, oak trees having wounds less than 6-inches wide will probably not lose any quality and no more than about 3 board feet in volume. Trees less than pole size are unlikely to lose any quality. Typically, the width of a single basal wound will be about 50 percent of tree circumference at stump height. This is caused by the "chimney effect" on the leeward side of the tree during a fire. Where wounds exceed 50 percent of circumference, mortality is much more likely because heat has killed the cambium on the windward as well as the leeward side.

As wounds exceed 50 percent the possibility of breakage is greater and tree vigor may be reduced due to loss of conducting tissue (fig. 4). The larger the wound or potential wound as indicated by bark blackening (Loomis 1973), the greater the probability of either immediate or delayed mortality. The probability of crown damage and loss in volume and grade of potential lumber is also greater.

Figure 4.--*Basal fire wounds frequently cause mechanical weakness due to decay and insect activity. This 19-inch black oak was 17 inches d.b.h. when wounded 14 years earlier; wound width at 1 foot was 41 inches--84 percent of circumference.*

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Shhhh...noise pollutes too!